



3 1176 00165 3782

NASA TECHNICAL MEMORANDUM

NASA-TM-76604

NASA TM-76604

WHERE ARE WE IN THE SPACE WAR?

J. H. Lee

NASA-TM-76604 19820003223

Translated from Monthly Korea, No. 6, June 1981, pp. 146-155.

LIBRARY COPY

SEP 8 1981

LANGLEY RESEARCH CENTER
LIBRARY, NASA
HAMPTON, VIRGINIA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

AUGUST 1981

STANDARD TITLE PAGE

1. Report No. NASA TM-76604		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle WHERE ARE WE IN THE SPACE WAR?				5. Report Date August 1981	
				6. Performing Organization Code	
7. Author(s) J. H. Lee				8. Performing Organization Report No.	
				10. Work Unit No.	
9. Performing Organization Name and Address Leo Kanner Associates Redwood City, California 94063				11. Contract or Grant No. NASw- 3199	
				13. Type of Report and Period Covered Translation	
12. Sponsoring Agency Name and Address National Aeronautics and Space Adminis- tration, Washington, D.C. 20546				14. Sponsoring Agency Code	
15. Supplementary Notes Translation from Monthly Korea, No. 6, June 1981, pp. 146-155.					
16. Abstract The article discusses space war and the use of laser weapons. It includes the divergent opinions of some American scientists on laser weapons. A comparison of the U.S. and Soviet attitudes is made. The author briefly discusses his proposal for producing a laser directly from sunlight without using solar panels.					
17. Key Words (Selected by Author(s))				18. Distribution Statement Unclassified-Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified		21. No. of Pages 16	22. Price	

WHERE ARE WE IN THE SPACE WAR?

J. H. Lee
Laser research director, NASA

The author came to the United States to Vanderbilt University from his position as Professor at Kyongbuk University; he worked as a laser research director for NASA Langley. He recently succeeded in converting solar energy directly to a laser and developed a new era in laser research.

Space War is No Longer a Fantasy

/146*

Many will remember that on May 12th, 2 years past its scheduled time, the United States' Space Shuttle Columbia was successfully tested while thousands impatiently watched it around the world. Propelled like a rocket and landing like an airplane, the Space Shuttle Columbia is expected to open up new frontiers in exploring the benefits of the space environment. It is certain that new dimensions will be added to astronomical observations, space communications, pharmaceutical products, national defense and other manufacturing technologies. Space shuttles can be used to carry machines, equipment and satellites to space stations to be assembled or repaired and then to be carried back to the earth. A researcher at NASA reports that by the year 1990 everyone will be able to travel back and forth from the earth to space stations on space shuttles, much like present-day airline travel.

As many people are aware, new scientific technologies are often developed first for military use before they are used by civilians. Actually, the first thirteen trips the Columbia will make will be exclusively reserved for the Air Force. Since many satellites for information and intelligence gathering will be put in orbit, it is difficult to ignore the possibilities of a war involving these satellites. A war involving search-and-destroy satellites equipped with sun lasers and lethal particle-beam rays is no longer a mere fantasy designed for science fiction enthusiasts, such as the movie Star

*Numbers in the margin indicate pagination in the foreign text.

Wars, but is becoming a reality, a war that will actually be waged over our heads.

The United States Plan for Laser Weapons

Simultaneously with the successful test take-off and landing of the Columbia, both the United States and Soviet Russia have rapidly accelerated their research in the development of laser weapons; the size of these two countries' commitment to this research is such that even scientists in other areas can feel its impact. According to The Enquirer, a weekly gossip newspaper, the United States Defense Department is expected to spend several million dollars to put laser weapons in space. Carried out under the secret code name Talon Gold, the Defense Department's plan can be seen as a miniature version of the Death Star in the movie Star Wars. According to the Talon Gold plan a laser weapon capable of several million watts of power¹ will be installed in a satellite by 1983 in orbit some 23,000 miles (37,000 km) above Earth. This laser weapon will be capable of locating and destroying any intercontinental ballistic missiles launched by any hostile country against the United States. According to another plan, a series of mirrors will be installed in a satellite which will reflect back to their targets strong laser beams directed from Earth. The Enquirer reporter reveals that the space laser weapon plan has an allocated budget of 105 billion dollars, some five times the amount spent for the Apollo moon-landing program by NASA. The United States Defense Department is said to be considering the possibility of creating a new branch of the military service for space, i.e., a space force that will plan and direct strategies for space war. /147

Simultaneously with the release of these unconfirmed rumors, General F. S. Holmes of the Direct Fire High Energy Lab announced that

¹The most powerful industrial laser, capable of drilling holes in a steel sheet, has 15 kilowatts of power; the Talon Gold laser has the power of several hundred such lasers.

at present the purpose of the laser weapon research is to estimate and evaluate the destruction capability and economic feasibility of lasers and that, for the year 1981, a budget of 125.5 million dollars has been approved. General Holmes also announced at an electronics and optics technology conference on November 17-18, 1980, that the primary focus of laser research ought to be to obtain basic knowledge about laser weapons and to explore the technology for increasing laser power and that, once the laser destruction capability demonstration held jointly by the Navy and Air Force is successfully completed, the laser weapons development program will begin in full force.

The Defense Department-backed laser program focuses on the combat use of lasers. The Air Force, for example, would like to develop a laser weapon for air-to-air combat with some emphasis also on the laser as an offensive weapon on fighters and as a defensive weapon on bombers. The Navy's interest in lasers stems from its protective function on Navy battleships and vessels against low-altitude missiles. Strategic laser weapons, those used in destroying intercontinental ballistic missiles or space satellites, are also being developed separately by the Defense Advanced Research Project Agency with a budget of 72.3 million dollars.

General Holmes reported that the Air Force plans in the very near future to conduct an experiment with the laser developed by the laser lab to test its capability to destroy an air-to-air combat missile in flight. The Air Force plans to use inexpensive gas-dynamic CO₂ laser equipment installed in a KC-135 aircraft. The target missile will have decreased kinetic energy and will not collide with the aircraft. According to recent reports, the Air Force conducted, in the middle of last January, the first phase of the laser weapon experiment -- the ground test of laser firing. Despite repeated firing of the CO₂ laser mounted inside the cockpit of a KC-135, precision control of the optical instruments was maintained. However, a full-scale in-flight test still belongs to the future.

The next laser destruction capability demonstration will be the Navy's Miracle (the Miracle Mid-Infrared Advanced Chemical Laser).

Miracle will be conducted on the White Sand missile firing site as a simulation of laser defense (this time a deuterium-fluoride laser against offensive weapons in flight). If this test is successful, the Defense Department will decide whether to go ahead with the full-scale development of strategic laser weapons. /148

According to General Holmes, the American program is radically different from the Soviet one, as is the American viewpoint. Presently no one believes that America is capable of making even a trial model. Laser weapons have not demonstrated that they can satisfactorily fulfill military needs even in war game experiments. The military will not enthusiastically support laser research until laser weapons are shown to perform technologically to their full satisfaction in war conditions.

Other military programs focus on research on support instruments and assembly parts. For example, the Army has a research lab for the ammunition case for the chemical laser. Its purpose is to develop a case that contains the chemical fuel and also a case that contains the used gas, deuterium fluoride (DF). Because of its indispensability in manufacturing a DF laser, the DF gas must be collected. Other important programs include the development of the guidance mechanism for search and pursuit. A light target director, called Sea-Light, used in the above-mentioned Miracle system, will require 10 million dollars for its development.

Despite its seemingly high cost, the laser is an economical device. In order to obtain an equal amount of power with conventional firearms, a defensive fighter airplane would require approximately \$300,000 to \$500,000; for a short-range fighter it would cost about \$20,000. On the other hand, the fuel for a DF laser costs only \$1000 or \$2000 for comparable power. The cost would be reduced further if the still cheaper CO₂ laser is used which would produce the same power for a few hundred dollars.

A Senate Committee Report Urges Laser Weapon Development

According to the Senate Arms Committee report, the laser program is gaining wider support among the public. The budget for the development of laser weapons had been growing steadily even before the presidential election. The Senate Committee report stated that the laser is included in the three most significant inventions of the twentieth century along with the atom bomb and integrated circuits and that the government should fully support the laser program. This report was prepared by H. Heflin, a Democratic senator from Alabama after a series of hearings on science, space and technology by the Senate committees on commerce, science and transportation.

This report, published in November 1980, emphasized the need for a positive effort in a more balanced and comprehensive laser development and application. The report urged the creation of an agency for the promotion of research a step beyond weapon development, such as laser-assisted fusion, isotope separation, long distance exploration, spaceship propulsion, solar-powered satellites capable of transmitting energy to the earth, and other laser-related applications and, in addition to the promotion of these programs, the control of laser-based secret weapons.

Admitting the diverse and often discordant opinions among scientists and military research engineers, the report requested that laser weapon development be realized as soon as possible. It also urged the Defense Department to set up an independent agency to monitor and control the research and development of laser weapons. Presently, four separate programs under the Army, Navy, Air Force and the Defense Department are being developed without a joint effort. The report pointed out the enormous cost involved in funding the development of a big laser system under four separate programs.

Denying many Defense Department officials' claims that the Soviets have not yet begun their laser development program, the report stated that no evidence has been presented in support of such claims. Senator Heflin remarked that the Soviets may already have developed

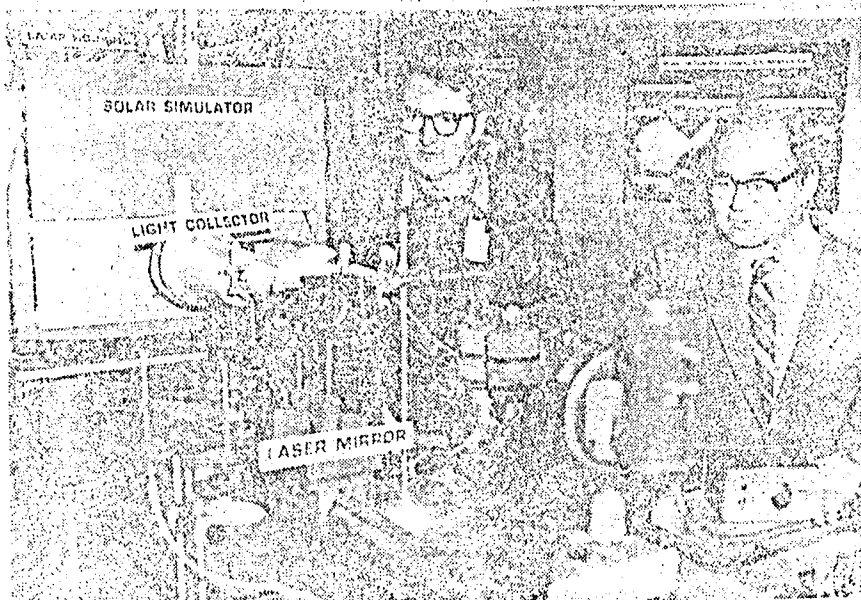
/149

warscale laser weapons after a witness' testimony that the Soviets are spending three to five times more for defense than the United States.

On the 20th of last November Senator Heflin submitted a bill for the promotion of laser technology application. This bill proposed the creation of the National Laser Laboratory which will monitor and control the funding of the laser programs under the Defense Department, the Energy Department, NASA, and the National Science Foundation. Because the Congress did not pass the bill before its December adjournment, the bill must be re-submitted in the next session.

Criticism Against Laser Weapon Development Also Wide

In contrast to the Senate Arms Committee's enthusiastic support of laser weapon development, there are people who oppose the laser as a military weapon and who desire to see research more along the line of defense against lasers. Two scientists at MIT report that strategic laser weapons are inefficient in comparison with the inexpensive defense devices against lasers. The conclusion and the proposal of this report are that laser research should be satisfied with



developing a strong laser, which then will be used for developing defensive devices against lasers. However, this opinion is ignored by President Reagan's advisers. This 109-page research report was published by M. Callaham (presently with Carnegie-Mellon University) and K. Tsipis Jr. around the middle of December. However, it was reported several days later that the Reagan transition team had recommended the development of laser weapons to be stationed in space. Such a laser weapons development plan was proposed a year ago by Democratic Senator M. Wallop, who is also President Reagan's adviser.

The Callaham-Tsipis report points out the continuing controversy on the effectiveness of laser weapons. They admit that laser energy capable of destroying satellites, airplanes and long-range missiles can be transmitted to its targets through the atmosphere when weather conditions are favorable. However, depending on weather conditions, the transmission of the laser can be interfered with, thus making laser weapons rather ineffective as defensive weapons and only marginally effective as offensive weapons. Offensive maneuvers can wait for favorable weather conditions, but defensive weapons must be able to react under any weather conditions.

According to this report, the laser weapons development will run into severe problems in such areas as target location, tracking and laying, and thus the development of actually usable laser weapon systems will not be easy. Even if intercontinental ballistic missiles are not equipped with a defensive mechanism against the laser, the sheer number of these missiles will force the laser weapons installed in satellites to reach a saturation point. Furthermore, these missiles can easily be equipped with some defensive mechanism against lasers, or some such counterattack plans can be devised -- it is at best questionable whether the present technology or the technology in the near future allows laser-equipped satellites to perform well under these unfavorable conditions.

The report also questions the economic feasibility of space laser weapons systems. This is because the satellites equipped with laser weapons will need some protective mechanisms for themselves, and also

there are other cheaper but equally effective combat devices. The report does admit that satellite-based laser weapons possess significant strategic value in comparison with land-based or airplane-based laser weapons and that they are safer from enemy attack. The report makes the following conclusion: Even though laser weapons are rather ineffective in actual combat situations, because they have enormously dangerous consequences in the nuclear arms race, the research into developing defensive devices against lasers must be focused on protecting ourselves from the increasingly sophisticated laser weapons of the future. Thus future laser research must develop laser weapons, if only to serve as models for developing defensive devices against them.

The Space Shuttle and Space War

The question of why humanity feels compelled to commit such enormously destructive acts as space wars does not properly belong to this article, but we can predict its likelihood by discussing how freely man will be able to use space. We can get an indirect glimpse at our space future by looking at the flight schedule of the recently tested Space Shuttle Columbia. The first cargo on the space shuttle is scheduled to be an environment-testing laboratory also designed to explore the earth's natural resources. One of the experiments to be performed in this lab is to find out if an accurate map of Earth's natural resources can be drawn. Another experiment involves determining ocean color to measure the population of sea organisms. Other experiments deal with such things as the atmospheric distribution of CO₂ and the space observation of lightning at its origin. Another experiment called LDEF (Long Duration Exposure Facility) is designed to discover the effects of various selected materials when they are placed for a long period in the space environment. These materials will be used in constructing space stations, and the experiment is designed to see if they can survive cosmic rays, meteorites and cosmic dust.

/151

The LDEF plan also includes an experiment that will carry the plant spores and seeds into space. This experiment was designed with

future space agriculture in mind; it attempts to find out about any anomalous effects in space. The space shuttle is also designed to return the satellite that is in the process of observing the sun's apogee and in 1985 to put into orbit a 45-foot astronomical telescope.

This new telescope is expected to fulfill the long-held desire of many astronomers to observe space outside Earth's atmosphere; it is expected to allow astronomers to see 350 times more space than before. The Space Shuttle will also carry into space a satellite that will be 23 feet long, a space lab inhabitable by humans and the first manned satellite designed by the European Space Research Center. Selected astronauts from West Germany, the Netherlands and Switzerland are undergoing tests and practicing in preparation for the space laboratory. The space lab has become a focus of interest in West Germany where the space laboratory plan is widely known. An ERNO spokesman states that Europeans have finally realized that the space venture is a profitable business. ERNO is the company that manufactured the space lab satellite. The purpose of many planned experiments on this space lab is to understand more about Earth's atmosphere and to perform long-distance ocean exploration. West Germany in particular is paying special attention to the gravity-free manufacturing environment of space. Their interests include: purer crystallization of electronic materials such as silicon, which will permit making faster and smaller computers; better pharmaceutical materials; and other new alloys combining materials that cannot be mixed on Earth. The space lab will consequently carry a melting furnace and many laboratory apparatuses for biology and chemistry experiments.

Japan Participates in Space Exploration

One of the most attractive devices in the space lab was designed by Japan. Japan, like many European countries, has a strong desire to participate in the space race and has made serious efforts to learn advanced space technology from NASA. Professor Obayashi explains that the Japanese plan will create an artificial aurora with an electron accelerator in space. The high-speed electrons emitted from the

accelerator will pass through the plasma already discharged from the satellite and make an artificial aurora either over Tokyo or Washington. A careful observer will be able to watch this aurora as a lighted band several miles long some 60 miles above the horizon. This experiment will help us understand how the electrons emitted from the electromagnetic sphere create natural auroras.

The New World of Earth's Orbit

Another dream that will be realized in the not too distant future is a large long-distance communication station built in space. This communication station will be able to handle 250,000 calls simultaneously and will allow people with special receivers to watch any television program anywhere in the world. This communication station is expected to revolutionize television telecommunication and popularize it among the masses. By the year 2010 the communication station costs alone will amount to \$40 billion to \$80 billion. The building plan for this communication station is progressing well. Rockwell International is manufacturing the joints for the mechanical arms used for remote control of the main post of the station structure. General Dynamics engineers are designing a transmission-reception antenna that opens like an umbrella. McDonnell Douglas is doing research in the design of a station habitable not only by astronauts but by maintenance and other workers. McDonnell Douglas and Grumman are working on a machine that will produce triangular structural beams which can be welded in space. These beams will become the structural support for the communication station. One engineer reports that this machine will be capable of producing a fourteen-mile long beam. These beams will be made of specially prepared synthetic material light enough to lift with one hand but strong enough to support the weight of a spaceship. /152

The Air Force Plans to Use the Space Shuttle

The United States Air Force will be the first customer of the space shuttle. The Air Force has already set up a special blast-off

location for its exclusive use at Vandenberg Air Force Base in California and has prepared a special secret space shuttle flight control room in Houston. These secret military plans are being put into operation. Because of their secret military nature the public will not know exactly what is planned, but the probable guesses are the following. One of the plans is to put into orbit at 23,000 miles above the earth a spy satellite for intelligence gathering -- it will be a complicated machine containing a one thousand foot (300 meter) diameter antenna. Another rumor has it that the Air Force has a plan to assemble a satellite at a lower altitude by 1985, but the purpose of this plan is unknown. By 1990 a satellite orbiting at low altitude may be necessary as a stopover station for space laborers. By that time there will be a large need for laborers to assemble or repair satellites orbiting at proper altitudes.

Soviet Russia's Space Shuttle Plan

The Soviet Union plan for space shuttle development is not well known, but according to some intelligence information, they seem to be involved in a smaller scale space shuttle program. Soviet Russia has gained a strong edge over America in the manned space program by repeatedly sending manned space ships into orbit while America was concentrating on the space shuttle program. The Soviet Union has improved the conventional rocket in an effort to assemble a large space station; the satellite where astronauts lived for a half year is still orbiting Earth. They plan to put an astronaut in a satellite continuously throughout the whole year for intelligence gathering. The Defense Department comments that Soviet Russia's steady progress in space is due to their continued commitment to space programs, unlike America, which suffers heavily from the constantly changing political climate. Senator Schmitt, a former astronaut, states: The United States must set a long-term plan for itself if it is going to remain a leader in this highly competitive space field. If we maintain the archaic thought that science and space research are luxuries, we will soon find ourselves in the position of the led, not the leader.

/153

Development of a Satellite for Solar Energy Production

The manufacture and operation of the above-mentioned space weapons and large satellites will need a supporting energy source, in particular, an energy producing device. The traditional energy source has been Earth-manufactured batteries or small-scale solar panels. But the new space programs demand a continuous, long-term, and large-scale energy supply. Consequently, one of the major foci of the space industry in the 80's will be to develop a large-scale energy production device. The first goal of the energy production plan will be to maintain an orbiter satellite for 60 days and a space lab to be carried into space by the space shuttle. The orbiter will carry an Earth-manufactured fuel source which will last 7 days and must use solar power for the remaining days. Such solar energy production must not only prolong the operation days of a satellite but must open the door to actual space industrial use. Designers for NASA are proposing a multipurpose "Sortie" system consisting of one orbiter satellite connected to a number of smaller satellites. Built up like a brick wall, several of these modules connected together will be able to provide greater energy production capability in addition to the energy necessary for each module's maintenance. At the present time two companies are in competition for the design and production of the module system; both module systems will be larger than any other solar panels previously put into orbit. TRW's solar panel has dimensions 150 feet long by 28 feet wide and the McDonnell Douglas panel is slightly smaller than TRW's. The largest solar panel in orbit now is 56 feet long and is attached to a satellite designed for tracking and data transmission. NASA's first projected goal in a solar energy generating satellite is an energy level of 25 kW after 5 years of use. The preliminary blueprints for this solar energy generating satellite reveal a large insulating mechanism protruding above the control room and solar panels like spread wings attached to the insulating mechanism perpendicularly, reminding one of a large shark fin cutting across space as if it were an ocean.

TRW's solar panel weighs some 28,000 lbs (12,700 kg), a little less than half of the space shuttle cargo limit. It is designed to

fold in a number of layers to leave some room in the space shuttle for other orbiter cargo. McDonnell Douglas' panel is designed to fill the entire space shuttle cargo area; however, this will not be a big problem. When the space shuttle reaches its orbit, the elephantine solar panels and the insulating mechanism will be released from the space shuttle cargo area; then the solar panels will spread open and begin energy production work. Such a solar energy production plant will be the base for energy supply during normal times. Scientists can travel to such a plant on a space shuttle with laboratory apparatus and experimental set-ups, which will run on the power generated by the plant; the equipment will be returned after a designated period. /154

Such an energy generating plant can also serve as an energy source for many scientific experiments and space industry jobs. The most important focus of this solar energy generating plant is its multi-purpose application. This plant will be connected to an orbiter such as the Sortie, but the orbiter must return to Earth after 60 days.

From then on, this solar energy generating plant must act as an independent satellite; and, when the need arises, it must be able to boost itself out of its present orbit for orbit change. When the energy need is low, it will go into a storage state, fold up 90% of its solar panels and rest the insulating mechanism. When the energy need increases, the solar panels will open up again for increased power.

Eventually this solar energy generating plant will break down; its life is estimated to be about 5 years.

In addition to the wear and tear on the solar panels, the plant is expected to suffer damages from collision with meteorites and cosmic dust, and the electronic control circuits are expected to have problems. The plant will not be thrown away like garbage but will be flown back on the space shuttle to Earth for repair. Such a procedure brings a revolutionary era in space technology; no longer will old satellites be discarded like garbage, but they will be reclaimed and reused.

Such a reclamation procedure allows us to see the economic feasibility of the space shuttle development. The above-mentioned 25 kV generating plant is only a first step in the economic benefits of the space shuttle.

After that, larger and more powerful plants can be developed. Following the brick wall principle, it should be possible to assemble a large communication station in orbit or to construct a space colony where man can live by adding an increasing number of modules.

The time is not far off when man will be able to settle in space, to live and to work there.

Solar Power and the Space War

The reason why we have surveyed only the peaceful use of solar power in space is because the military solar development is top secret information; however, it is not difficult to speculate on the use of solar power for military purposes.

Clearly, it is safe to assume, many weapons to be employed in space, particularly laser devices, will need an enormous power source for their operation. Since laser efficiency is generally below 1%, a welding laser with 10 kV power will need a 1000 kV power source. Since the laser for space weapons requires on million watts of power, even if laser efficiency improves to 10%, we are talking about a number in the neighborhood of 10 million watts (100,000 kV) of power. Such power equals the total output of a large nuclear reactor power generator. At one time the proposal to orbit a nuclear reactor in space was considered but was abandoned because of the possibility of polluting space with it. Building a solar power generator plant could be considered the first step toward a realistic development of laser weapons for space war. /155

The large-scale construction of a solar power generator in space parallels the development plan of a solar power satellite for peaceful use. Abbreviated as SPS, this satellite will convert its solar

energy to microwaves to be transmitted to Earth, where antennas will receive the microwaves and convert them back to electrical energy to be sent to energy-hungry places in the world.

Such a plan has attracted the attention of many people, particularly at a time when we are facing a severe shortage of oil and other natural resources. This plan has encountered much criticism, however, because of the possible environmental pollution problems when many millions of kW of microwaves are passing through Earth's atmosphere and also the heavy demand for land due to the large dimensions of the receiver antennas.

The author has proposed recently a new idea that will eliminate the middle step of using solar panels in space to generate electricity and will produce lasers directly from sunlight. Since the successful results of this author's experiment entitled "The World's First Sunlight Produced Gas Laser," were published by NASA, they have become widely known through many popular journals (see, for example, Popular Science, May 1981, p. 21); only an abbreviated description will be presented here.

First, a direct sunlight produced laser device does not need an intermediate power generator, thus reducing the weight of the machine components to be transported to space. Second, this device transmits laser light, 100,000 times shorter in wavelength than microwaves, decreasing the size of the antennas needed significantly. Another advantage is that since it reduces the overall number of energy conversion steps, the efficiency of the entire system is expected to increase, thus enabling the device to be practical in both Earth-to-space or space-to-space applications. This system will find its application, of course, in military functions, but it will also be used in many peaceful space activities.

For example, when a space exploration satellite is investigating a planet which is distant from the sun, on a long-term basis, the sunlight may not be sufficiently strong to run the solar panels for generating power; yet it may be sufficiently strong to produce lasers-

^{from} using the direct sunlight produced laser device. This laser can be used to run the solar panels.

Also, this laser device can transmit laser energy to small satellites sent from a mother space ship to continue their work without carrying an additional energy source on board. Or, a strong laser can be activated ~~on~~ high altitude airplanes or space shuttles as an energy boost, thus reducing their carry-on fuel requirement.

Under the heading "Where are we in the space war," this paper has introduced three areas of interest: space war weapons development, the space shuttle development to put these weapons into orbit, and the solar power generator development to supply energy for the operation of these weapons. We regret that, because these areas fall under highly sensitive, top secret information, many of the conclusions had to be conjectures based on peaceful development projects. We emphasize again that space war is no longer confined to the lively imagination of science fiction writers but that the time has come when it can be realized in the skies above our heads and that the possibility of space war has renewed the arms race between Soviet Russia and the United States with a new twist and new possibilities.